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Title Page

Running head:

Outcomes of horses treated with removal of a laryngoplasty prosthesis

Article Title:

Outcomes of horses treated with removal of a laryngoplasty prosthesis

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Conflict of Interest:

The authors declare no conflict of interest related to this report.

Presentation:

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1 **Abstract:**

2 **Objectives:** (i) To determine the proportion of horses treated by laryngoplasty prosthesis
3 removal (LPR) for complications associated with prosthetic laryngoplasty (LP), (ii) to
4 determine the reason for LPR, and (iii) to determine the outcome of horses undergoing
5 LPR to manage iatrogenic coughing / dysphagia.

6 **Study design:** Retrospective study

7 **Sample Population:** Client-owned horses treated with LP (n=1202) and LPR (n=58)

8 **Methods:** Clinical case records were reviewed to determine the number of horses treated
9 with LP and LPR by the same surgeon. Historical, clinical, endoscopic and surgical data
10 were extracted for those horses undergoing LPR. Long term outcome was assessed by
11 questionnaire.

12 **Results:** The proportion of horses treated with LP subsequently treated with LPR by the
13 same surgeon was 3.5% (42/1202). Coughing / dysphagia was the reason for LPR in 90%
14 (52/58) of horses. Sufficient follow-up to determine outcome in horses undergoing LPR
15 for coughing / dysphagia was available in 32 horses. Arytenoid abduction grade at the
16 time of LPR did not significantly influence clinical response ($p=0.416$). Presenting
17 clinical signs resolved following LPR in 21/32 (66%) horses and 24/32 (75%) horses
18 returned to exercise.

19 **Conclusions:** Coughing / dysphagia was the most common reason for LPR. Clinical
20 signs improved in the majority of horses following LPR.

21 **Clinical significance:** Laryngoplasty prosthesis removal can be a useful treatment option
22 for horses affected with unmanageable coughing / dysphagia caused by LP.

Introduction:

Prosthetic laryngoplasty (LP) is the mainstay of treatment for horses with recurrent laryngeal neuropathy,¹⁻⁴ but it is recognized to have a high rate of post-operative complications in comparison with other surgeries performed to treat dynamic upper airway obstructions. Short term complications include prosthesis failure, loss of abduction, seroma formation, incisional dehiscence and coughing.^{5, 6} In the longer term there may be loss of abduction^{4, 7}, chronic coughing⁴⁻⁷, dysphagia⁷, with or without the nasal reflux of ingesta⁴, aspiration pneumonia^{3, 8}, inflammatory airway disease, exercise induced pulmonary haemorrhage⁹, esophageal incompetence¹⁰, dysfunction of the soft palate¹¹ and other forms of dynamic airway obstruction.^{12, 13}

Coughing resulting from dysphagia is the most common complication following LP, with studies reporting 5-57% of horses affected.^{1-3, 5-8, 14-17} Several mechanisms to explain the dysphagia following LP have been proposed: (i) reduced protection of the rima glottidis during swallowing due to inability to adduct the arytenoid cartilage⁷ and removal of the vocal cords^{1, 7}; (ii) damage to the muscles of the upper esophagus, their innervation or the peri-esophageal fascia and adventitia^{10, 14, 18}; (iii) development of adhesions lateral to the larynx¹¹, between the arytenoid and thyroid cartilages, and to the cranial esophagus or esophageal diverticulum. Many horses with complications following LP can be managed conservatively. However, persistent or severe coughing / dysphagia, which affects the ability to be ridden, quality of life, or results in an increased risk of developing respiratory infection or aspiration pneumonia, may be an indication for laryngoplasty prosthesis removal (LPR).^{3, 5, 6, 10, 15, 17, 19} Laryngoplasty prosthesis removal may lead to

an improvement in clinical signs with reduction of coughing / dysphagia where over-abduction is present or where rima glottidis protection is reduced. More recently alternative treatments to LPR are being investigated for the treatment of dysphagia following LP, including laryngeal tie forward surgery and vocal cord bulking.²⁰ The proportion of LP horses in which LPR is subsequently performed is not known.

Despite frequent reports of complications following LP, the authors are not aware of any published studies describing the outcomes following LPR although such information would assist decision-making for veterinary surgeons confronted with intractable complications of LP. The specific objectives of this study were: (i) to determine the proportion of horses that had previously undergone LP subsequently requiring LPR by the same surgeon; (ii) to determine the main reasons for LPR; and (iii) to determine the outcome of horses undergoing LPR for coughing / dysphagia. Secondary objectives were to determine the prevalence of arytenoid over-abduction in horses treated with LPR; to determine whether delay in performing LPR influenced outcome; and to determine whether arytenoid abduction grade at the time of LPR influenced outcome. We hypothesize that removal of the prosthesis can lead to resolution of coughing / dysphagia.

Materials and Methods

Animals:

A retrospective case study reviewing clinical case records, with either a telephone or paper questionnaire follow up, was undertaken. The study was approved by the University of Bristol animal welfare and ethical review board. All horses, for which records were available, that had undergone LP or LPR between September 2003 and June 2017 were included in the initial part of the study to determine the proportion of LP horses subsequently requiring LPR by the same surgeon. The horses that underwent LPR were included in the latter parts of the study to determine the reasons for LPR and to determine the outcome of horses undergoing LPR for coughing / dysphagia. Detailed information from case records was only extracted for LPR horses.

Laryngoplasty Prosthesis Removal Procedure:

All LPR were performed by a single surgeon [JGL] at multiple equine hospitals. The original LP records were reviewed (if available) to establish the nature and number of prosthesis(es) used, to aid LPR surgical planning. Food was withheld from the horses for >9 hours before surgery and preoperative antimicrobial were administered. The surgical approach for LPR was the same as for LP.¹⁵ The knot of the prosthesis(es) were most commonly located between the caudal border of the cricopharyngeus muscle and the caudal border of the cricoid cartilage. The course of the prosthesis was followed caudally and rostrally, and the prosthesis was transected and subsequently withdrawn through the arytenoid and cricoid cartilages. This process was repeated for removal of a second

prosthesis, if present. Care was taken to minimize disruption to the fibrous tissue surrounding the prostheses.

Data Collection:

The clinical case records for LP and LPR were used to determine the proportion of LP horses subsequently requiring LPR by the same surgeon. The clinical case records for all horses treated with LPR were reviewed to determine the reason for LPR. The case records for horses treated with LPR for the primary complaint of coughing / dysphagia had the following information extracted: age, breed, sex, use, date of LP, arytenoid abduction grade at time of LP, surgeon who performed LP, prosthesis material, whether ventriculocordectomy (VC) was performed, date of LPR, arytenoid abduction grade and endoscopic findings at time of LPR, and complications that occurred during the LPR surgery or hospitalization period.

Standing endoscopy was performed in all horses by the surgeon before LPR to allow assessment of arytenoid abduction and food contamination of the nasal passages, pharynx, larynx and trachea as an indication of the degree of dysphagia. Arytenoid abduction was graded using a 5-point system¹ whereby the greater the abduction, the greater the grade (table 1). Grade 5/5 was considered over-abduction, grades 3/5 and 4/5 were considered good abduction and grades 1/5 and 2/5 were considered no or poor abduction respectively. Post-operative endoscopy was typically performed by the referring veterinary surgeon.

108 Questionnaire:

109 Follow up information was obtained from questionnaires completed by either the
110 referring veterinary surgeon, owner or trainer. All questionnaires were completed
111 between May 2015 and June 2017. Cases were considered lost to follow up if the
112 referring veterinary surgeons, owner or trainer of the horse were unable to provide
113 sufficient horse details or following at least 5 failed attempts to contact. The
114 questionnaire consisted of 13 questions, of which 11 were open- and 2 close-ended, with
115 the opportunity to provide additional information. Information obtained from the
116 questionnaire included: the reasons for LPR, when the clinical signs were first reported
117 following LP, clinical response to LPR, change in respiratory noise during exercise,
118 subsequent performance and the owner's overall perception of the success of the surgery
119 (Appendix 1).

121 Three categories were developed to classify the outcome following LPR: 'no response' if
122 there was no or minimal change in the clinical signs exhibited following LPR; 'partial
123 response' if a beneficial change in the clinical signs was reported, such that the amount of
124 coughing / dysphagia appeared reduced, but on-going dysfunctions remained; 'resolution'
125 if the presenting clinical signs were no longer exhibited.

127 Data Analysis:

128 Data were entered into Microsoft Excel and descriptive information was derived from
129 this database. Statistical analyses were performed using SPSS Statistics version 24 (IBM
130 Corp, Armonk, NY). Numerical variables (age and time between LP and LPR) were

131 assessed for normality graphically and by use of the Shapiro-Wilk test. A Kruskal-Wallis
132 test was used to assess whether time span between LP and LPR varied depending on
133 outcome, and whether arytenoid abduction grade at the time of LPR was associated with
134 outcome. Statistical significance was set at $p < 0.05$.

135

Results:

Demographics:

During the study period 1,202 horses had LP performed by JGL to treat the presenting signs of recurrent laryngeal neuropathy. A total of 58 horses underwent LPR (figure 1) in the same period. For 42/58 (72%) of the removal procedures the same surgeon had performed the original LP with different surgeons performing the original surgery in the other 16 horses. The proportion of LP horses subsequently treated with LPR by the same surgeon was 3.5% (42/1202). Surgeons elsewhere may have removed a laryngoplasty prosthesis from others in the group of 1,202 horses, however that information was not available as part of the existing clinical records.

The primary reason for LPR was coughing and/or dysphagia in 52/58 (90%) horses, discharging tract from prosthesis infection in 3/58 (5%) horses and abnormal respiratory noise in the remaining 3/58 (5%) horses. The focus of this paper is to report the outcomes of horses subjected to LPR that presented with signs of coughing and/or nasal discharge containing food material, both indicative of dysphagia, and only these horses will be discussed hereafter. Fifty-two horses presented for LPR due to signs of coughing / dysphagia, questionnaires were completed for 36 horses however; the useable response rate was 32/52 (62%) (figure 1).

The final population of 32 horses included 27 geldings, 1 entire male and 4 mares. There were 13 Thoroughbreds (11 racehorses and 2 eventers), 13 mixed breeds (4 eventers, 8 hunters and 1 hacking), 4 Warmbloods (2 dressage, 1 showjumper, and 1 eventer) and 2

horses for which both the breed and use were unknown. Of the 32 horses the median age at the time of LPR was 7 years (range 2 to 12 years). The exact date of the original surgery was unknown for 6/32 (19%) horses, for the remainder the median time between LP and LPR was 8 months (range 3 months to 5 years).

Original Laryngoplasty:

All horses, bar one, had left sided LP, and all LP surgeries were performed under general anesthesia. All horses had a VC procedure performed either at the time of, or before, LP. For the 20/32 (63%) horses in which surgery was performed by the author, 9 had unilateral (left sided) vocal-cordectomy and bilateral ventriculectomy and 11 had bilateral VC. All VCs were performed using a surgical approach via a laryngotomy incision. A range of prosthesis material were used including; monofilament polyamide [Ethilon®]^A (n=14), combination of monofilament polyamide [Ethilon®]^A and braided polyethylene and polyester [Fibrewire®]^B (n=8), polyethylene terephthalate [Ethibond®]^A (n=4), combination of monofilament polyamide [Ethilon®]^A and polyethylene terephthalate [Ethibond®]^A (n=1), and stainless steel (n=1). The prosthesis material was not recorded in 4 cases. The abduction grade during LP, assessed by intra-operative endoscopy, was grade 4/5 in all 20/32 (63%) cases for which JGL was the surgeon.

Clinical signs:

The onset of coughing / dysphagia following LP was immediate in 11/23 (48%) horses, and in 12/23 (52%) horses the signs became apparent later. The time delay between LP and onset of coughing / dysphagia ranged from 6 weeks to 3 months in 6/12 (50%)

horses, approximately 12 months in 3/12 (25%) horses, over 3 years after LP in one horse and was unknown in the remaining 2/12 (17%) horses. No horse was able to undertake ridden exercise before LPR due to the severity of clinical signs. Coughing was reported in 31/32 (97%) horses and nasal discharge containing food material, indicative of dysphagia, in 31/32 (97%) horses.

Endoscopic Examination:

During endoscopic examination 26/32 (81%) horses had food material was present at the nostrils, nasal passages, pharynx or trachea. One horse had no food material observed during endoscopy despite the presenting complaint by the owner of reflux of both food and water when eating. The degree of food contamination observed on endoscopy was not recorded in the remaining 5/32 (16%) horses. The time between last eating and endoscopy was not recorded for any horse. The median arytenoid abduction grade at the time of LPR for the 32 horses was grade 3/5 (range 1/5 to 4/5) (table 2). No horse was over-abducted (grade 5/5).

Laryngoplasty Prosthesis Removal:

All horses had previously been treated with conservative medical management without success and LPR was considered a last resort. All LPRs were performed under general anaesthesia with no complications reported during the general anaesthesia or surgery. The only complication post-surgery was reported in a single horse that developed a seroma around the incision, which resolved with drainage via needle aspiration.

205 Outcomes:

206 Following LPR 8/32 (25%) horses showed no response in clinical signs of coughing /
207 dysphagia, 3/32 (9%) horses had partial response with a reduction in clinical signs, and
208 21/32 (66%) horses had resolution with elimination of the presenting clinical signs of
209 coughing / dysphagia. The owner's perception of whether the LPR was successful
210 directly mirrored the results of clinical response outlined above. Arytenoid abduction
211 grade at the time of LPR did not significantly influence clinical response ($p=0.416$) (table
212 2). Similarly the interval between LP and LPR did not significantly influence the clinical
213 response to LPR ($p=0.655$).

214
215 Endoscopy was performed by the referring veterinary practice within the first week
216 following LPR and at variable times thereafter. Arytenoid abduction grade and food
217 contamination were not consistently recorded. No horse underwent exercising endoscopy
218 to evaluate arytenoid stability. For 12 horses, the owner was able to provide a subjective
219 comparison of respiratory noise during exercise, and in 6 of 12 (50%) a louder respiratory
220 noise was reported after LPR compared with after LP. All 6 horses had arytenoid
221 abduction grade 3/5 or 4/5 before LPR.

222
223 Following LPR 24/32 (75%) horses returned to ridden exercise (figure 2), and 6 of the 24
224 horses resumed high level athletic performance including: one national hunt racehorse
225 and 5 event horses competing at intermediate or advanced international level
226 (CCI**/CCI***). Overall, 3 of the 8 horses classified as having no response to LPR
227 returned to low level exercise although continued coughing during exercise was reported.

228 For the 11 racehorses, 7/11 (64%) were able to return to ridden exercise however, only
229 one horse was able to return to racing (national hunt) with the remaining 6 horses retiring
230 to a lower level of exercise including hunting/eventing (n=4) and hacking (n=2).

Discussion:

This is the first study to report the clinical outcomes following LPR for the management of coughing / dysphagia. Although it is recognized that other surgeons may have removed laryngoplasty prostheses from individuals included in the 1202 horses in this study, the results show that the proportion of horses that underwent LPR is not less than 3.5%. Consistent with the existing literature on complications following LP, coughing / dysphagia were confirmed to be the most common reason for LPR.^{3, 5, 6, 10, 15, 17, 19} Unmanageable coughing / dysphagia necessitating LPR occurred in horses with both poor and good arytenoid abduction, with no horse classified as being over-abducted. Following LPR 66% of horses had resolution of coughing / dysphagia and 75% were able to resume ridden exercise. The time frame between the original LP and the LPR did not adversely affect the outcome.

Coughing and dysphagia following laryngoplasty:

Due to the nature of LP, some dysphagia in the immediate post-operative period is regarded as inevitable.¹⁰ Previous studies have shown that 22-57% of horses display coughing / dysphagia in the short term^{3, 14, 16}, with 5-43% of horses continuing to display signs long term.^{1, 3, 7, 16, 17} The causes of coughing / dysphagia following LP are not completely understood, with several mechanisms proposed. Over-abduction of the arytenoid cartilage following LP is proposed to result in reduced protection of the rima glottidis during swallowing, with the incidence of coughing / dysphagia increasing in parallel with greater surgical abduction.⁷ However, in the present study unmanageable dysphagia occurred in horses with both 'good' abduction (grades 3/5 and 4/5) and no or

poor abduction (grades 1/5 and 2/5) with no horse having over-abduction of the arytenoid (grade 5/5). The clinical improvement in 4/6 (67%) horses with no/poor abduction suggests that the presence of the suture, and not the degree of abduction, was contributory to the coughing / dysphagia.

The prosthesis material most commonly used was monofilament polyamide [Ethilon®]^A which is considered to be inert, however, it is conjectured that the knot or the cut free ends may cause irritation. Histopathology of local tissues was not performed to evaluate any inflammatory response but in a previous case report fibrosis and thickening of the cricopharyngeus and thyropharyngeus muscles was evident on post mortem examination¹⁰, supporting this hypothesis. A fibrous tissue response may compromise local innervation and muscle function associated with deglutition. A recent study also reported that the esophageal adventitia adjacent to the muscular process was frequently penetrated during LP,¹⁸ which is an alternative mechanism by which the suture could impede the normal function of the proximal esophagus¹⁴.

Laryngoplasty Prosthesis Removal:

Many horses with lesser degrees of coughing / dysphagia following LP can be managed successfully with conservative management and medical treatment, and remain useable without LPR. Laryngoplasty prosthesis removal is often regarded as a ‘last resort’ salvage procedure performed in the small number of cases where all other treatment options have failed adequately to resolve the presenting clinical signs and complications following LP. Hawkins (2015)¹⁵ suggested that the prosthesis should not be removed before 60 days

post LP to allow fibrous connective tissue formation around the muscular process to form and thereby prevent loss of abduction after prosthesis removal. No horse in the present study had the prosthesis removed within 60 days and the time period between LP and LPR did not influence outcome. Therefore, veterinary surgeons should fully explore all medical and conservative options before opting for LPR without there being a detrimental effect on the outcome.

Adhesions can develop at several locations following LP and there are conflicting views on the merits of breaking these down at the time of the LPR. On the one hand, minimal disruption to the adhesions between the arytenoid and thyroid cartilages is thought to help maintain a degree of abduction and stability of the arytenoid cartilage²¹ and reduces trauma to the soft tissues. On the other hand, adhesions and scar tissue around the esophageal diverticulum and lateral to the larynx may physically restrict normal esophageal function and laryngeal advancement¹¹ - breaking these adhesions down may aid return to normal mechanical function. During LPR in the cases reported here, an attempt was made to minimize the breakdown of adhesions in the expectation that this tissue would contribute to on-going arytenoid abduction.

Outcome:

Outcome was considered in several ways; change in clinical signs of coughing / dysphagia, change in respiratory noise and resumption of ridden exercise. Laryngoplasty prosthesis removal resulted in the resolution of coughing / dysphagia in 66% of horses. Evaluation of respiratory noise was based on subjective assessment rather than by

objective sound analysis. Assessment of noise required recall of historical information (from up to 9 years earlier), and as such should be interpreted with some caution. An increase in respiratory noise following LPR compared with when the prosthesis was in situ was reported in 50% of horses in which subjective comparison was possible. The most likely cause is loss of arytenoid stability and abduction following LPR, but this was not confirmed by exercising endoscopy.²² Immediately before LPR none of the horses could fulfil their intended use due to the severity of clinical signs. Following LPR 75% of horses were able to resume ridden exercise. Although some individuals can undertake a high level of athletic performance, most racehorses were unable to return to race training.

Study Limitations:

The main limitations of this study are the protracted period over which a retrospective survey has been applied, historical anamnesis, recall over a prolonged time frame and using subjective assessments of coughing, dysphagia and respiratory noise made by multiple people. Information on long term changes in arytenoid abduction, or arytenoid stability during exercise by overground or treadmill endoscopy was not available. In addition, the long interval between LPR and questionnaire may lead to some unreliability over historical information and did result in 20/52 (38%) horses not being suitable for inclusion through a lack of follow up or poor-quality information on the questionnaires.

Future Investigations:

Diagnostic techniques such as exercising endoscopy and laryngeal ultrasonography that are widely performed today were not routinely deployed 10-15 years ago. Thus, while

some useful conclusions may be drawn from the findings here, further studies to investigate coughing / dysphagia are required and revisiting older techniques such as fluoroscopy¹⁹ may also be helpful to discriminate between those cases where LPR would be helpful and those where alternative solutions should be sought. The information presented in this study, along with results of other treatment options such as injection of bulking agents into the vocal cord²⁰ will allow the development of a systematic approach to understanding the cause of coughing / dysphagia post LP and deciding upon the most appropriate treatment for each individual.

Conclusions:

In conclusion, a small proportion of horses undergoing LP may require LPR, primarily due to unmanageable coughing / dysphagia. For some horses, the presence of the prosthesis rather than the arytenoid abduction was contributory to the coughing / dysphagia. Laryngoplasty prosthesis removal can resolve coughing / dysphagia induced by LP and should be considered as a potential treatment option for affected horses.

Manufacturer Details:

A = Ethilon® & Ethibond®: Ethicon, Johnson & Johnson Medical N.V., Belgium.

B = Fibrewire®: Arthrex, Inc. Florida, USA.

References:

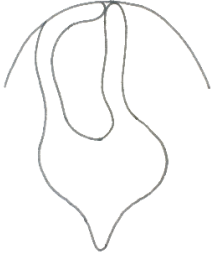
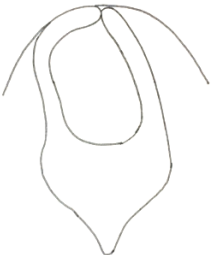
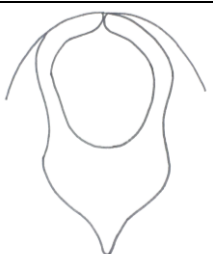
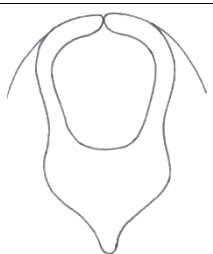
- [1] Russell AP, Slone DE. Performance analysis after prosthetic laryngoplasty and bilateral ventriculectomy for laryngeal hemiplegia in horses: 70 cases (1986 – 1991). *J Am Vet Med Ass.* 1994; 204: 1235 – 1241.
- [2] Kidd JA, Slone DE. Treatment of laryngeal hemiplegia in horses by prosthetic laryngoplasty, ventriculectomy and vocal cordectomy. *Vet Rec.* 2002; 150: 481-484.
- [3] Hawkins JF, Tulleners EP, Ross MW, Evans LH, Raker CW. Laryngoplasty with or without ventriculectomy for treatment of left laryngeal hemiplegia in 230 racehorses. *Vet Surg.* 1997; 26: 484-491.
- [4] Ducharme NG, Cheetham J. Abnormalities of the upper airway. In: Hinchcliff KW, Kaneps AJ, Geor RJ, ed. *Equine Sports Medicine and Surgery*. 2nd ed. United Kingdom, Saunders Elsevier; 2014: 568-572.
- [5] Froydenlund TJ, Dixon PM. A review of equine laryngoplasty complications. *Equine Vet Educ.* 2014; 26: 98-106.
- [6] Biasutti S, Dart AJ, Jeffcott LB. A review of recent developments in the clinical application of prosthetic laryngoplasty for recurrent laryngeal neuropathy: Indications, complications and outcome. *Equine Vet Educ.* 2017; 29: 337-345.
- [7] Dixon PM, McGorum BC, Railton DI, Hawe C, Tremaine WH, Dacre K, McCann J. Long-term survey of laryngoplasty and ventriculocordectomy in an older, mixed-breed population of 200 horses. Part 1: Maintenance of surgical arytenoid abduction and complications of surgery. *Equine Vet J.* 2003; 35: 389-396.

- 363 [8] Strand E, Martin GS, Haynes PF, McClure JR, Vice JD. Career racing
364 performance in Thoroughbreds treated with prosthetic laryngoplasty for laryngeal
365 neuropathy: 52 cases (1981-1989). *J Am Vet Med Ass.* 2000; 217 (11): 1689 - 1696.
- 366 [9] Mason BJ, Riggs CM, Cogger N. Cohort study examining long-term respiratory
367 health, career duration and racing performance in racehorses that undergo left-sided
368 prosthetic laryngoplasty and ventriculocordecotomy surgery for treatment of left-sided
369 laryngeal hemiplegia. *Equine Vet J.* 2013; 45: 229-234.
- 370 [10] Barakzai SZ, Dixon PM, Hawkes CS, Cox A, Barnett TP. Upper esophageal
371 incompetence in five horses after prosthetic laryngoplasty. *Vet Surg.* 2015; 44: 150-155.
- 372 [11] Barnett TP, O'Leary JM, Dixon PM, Barakzai SZ. Characterization of palatal
373 dysfunction after laryngoplasty. *Equine Vet J.* 2014; 46: 60-63.
- 374 [12] Compostella F, Tremaine WH, Franklin SH. Retrospective study investigating
375 causes of abnormal respiratory noise in horses following prosthetic laryngoplasty. *Equine*
376 *Vet J.* 2012; 44(43): 27-30.
- 377 [13] Davidson EJ, Martin BB, Rieger RH, Parente EJ. Exercising videoendoscopic
378 evaluation of 45 horses with respiratory noise and/or poor performance after
379 laryngoplasty. *Vet. Surg.* 2010; 39: 942-948.
- 380 [14] Goulden BE, Anderson LG. Equine laryngeal hemiplegia. Part III. Treatment by
381 laryngoplasty. *N Z Vet J.* 1982; 30: 1-5.
- 382 [15] Hawkins JF. Evaluation and management of the horse with dysphagia following
383 prosthetic laryngoplasty. In: JF Hawkins, ed. *Advances in Equine Upper Respiratory*
384 *Surgery*, Wiley Blackwell; 2015: 57-60.

- 385 [16] Ducharme NG, Hackett RP. The value of surgical treatment of laryngeal
386 hemiplegia in horses. *Compend Contin Educ Pract Vet* 1991; 13 (3): 473–5.
- 387 [17] Ahern BJ, Parente EJ. Surgical complications of the equine upper respiratory
388 tract. *Vet Clin N Am Equine Pract* 2008; 24: 465 – 484.
- 389 [18] Brandenberger O, Pamela H, Robert C, *et al.* Anatomy of the vestibulum esophagi
390 and surgical implications during prosthetic laryngoplasty in horses. *Vet Surg.* 2018; 47
391 (7); 942-950
- 392 [19] Heffron CJ, Baker GJ, Lee R. Fluoroscopic investigation of pharyngeal function
393 in the horse. *Equine Vet J.* 1979; 11 (3): 148-152.
- 394 [20] Ducharme NG. Equine upper airways – intersection of evidence based data,
395 emerging discoveries and the veterinary art. In: *Proceedings of the 62nd AAEP*
396 *convention*, Orlando, Florida; 2016: 107.
- 397 [21] Fulton IC, Anderson BH, Stick JA, Robertson JT. Larynx. In: JA Auer, JA Stick,
398 ed. *Equine Surgery*. 4th ed. St Louis, MO: Saunders Elsevier; 2012: 592-622.
- 399 [22] Barnett TP, O’Leary JM, Parkin TDH, Dixon PM, Barakzai S. Long-term
400 maintenance of arytenoid cartilage abduction and stability during exercise after
401 laryngoplasty in 33 horses. *Vet Surg.* 2013; 42: 291-295.

402 **Table 1**

403 Table 1 contains schematic drawings and a description of the abduction grading system
 404 used to grade arytenoid cartilage abduction following LP, based on the scale first
 405 published by Russell and Slone (1994).¹

Grade	Description	Drawing
1	The arytenoid cartilage is positioned at the vertical midline	
2	The arytenoid cartilage is in the normal resting position	
3	The arytenoid cartilage is abducted past the resting position but not touching the pharyngeal wall	
4	The arytenoid cartilage is contacting, but does not depress the pharyngeal wall	


5	<p>The arytenoid cartilage depresses the pharyngeal wall</p>	
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TABLE 2

Table 2 displays the arytenoid abduction grades at the time of LPR for the 32 horses. The primary outcome following LPR was the improvement in clinical signs of coughing / dysphagia which was categorized as resolution, partial response and no response.

Abduction Grade	1	2	3	4	5	Total
Number of horses	3	3	24	2	0	32
Outcome						
Resolution	2	1	17	1	0	21
Partial response	0	1	1	1	0	3
No response	1	1	6	0	0	8